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Phytoplankton in the vicinity of the "Severnyi polyus-22" drifting station

by T.V. Belyayeva

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During the drift of the "Severnyi polyus-22" station from May to October 1975, a series of hydrobiological investigations was conducted to study the biological productivity of the Arctic Basin. The purpose of our work was to study the flora and seasonal distribution of the phytoplankton.

Material and Method

The material for this investigation consisted of phytoplankton collected with the help of a bathometer, and of samples taken from leads in the vicinity of the drifting station (82°54'-84°15'N and 166-168°W); a sample of ice was also processed. The bathometric samples were taken with the help of a 10-litre plastic bathometer from the 0, 10, 25, 50, 100, 200 and 300 m levels. From the end of June, i.e. from the time the snow began to melt and leads began to form, samples were taken with a bucket from the areas of open water (15 stations from June 25th to Oct 14th). Forty-seven samples were processed in all. Of these, 18 bathomet-

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*The numbers in the right-hand margin are the pages of the Russian text - translator

ric samples (3 stations - May 22nd, June 9th and 24th) and 5 samples from leads (June 25th and 28th, July 3rd and 11th) were processed by the method of concentration on membrane filters. As a result of the processing of these samples, we found that the abundance of the phytoplankton in them (even in parallel samples) was by one and two orders of magnitude lower than in samples taken by the sedimentation method. Apparently, a large part of the phytoplankton cells stuck to the filters, and so we could use only sedimentation samples for quantitative determination of the phytoplankton. All the samples were collected by I.A. Melnikov during the drift of the SP-22 station [1976], and then passed on to us for processing. We would like to take this opportunity to thank him for providing us with this material.

A part (2-10 litres) of the samples processed by the sedimentation method was taken and fixed in 5% Formalin, allowed to settle and then siphoned off. Further processing of the samples was carried out in Moscow. It consisted in the following. The samples were allowed to settle for 3-4 weeks, after which the water above the sediment was very carefully removed with a pipet and the sample reduced to a 10 ml volume. Determination and counting of the algae were carried out in a 0.05 ml Nozzhot* counting cell, counting 2 cells at a time with 7x20 or 7x40 magnification. The 24 samples processed by the sedimentation method covered the period from July 7th to October 14th; at three bathometric stations (st. 12 on Aug. 27th, st. 15 on Sept. 14th and st. 17 on Oct. 14th), the samples were taken from the 10, 25, 50, 100 and 200 m levels. (134)

***spelling conjectural - translator**

Results

S p e c i e s c o m p o s i t i o n. The flora of the study area consists predominantly of diatomaceous algae. The role of dinoflagellates, silicoflagellates and blue-green algae is insignificant. Fifty-two species of diatoms have been identified in all. It should be said that the number of diatom species identified by us is close to the number identified by other authors for corresponding areas of the Arctic Basin [Shirshov, 1937; Usachev, 1961; Kawamura, 1967]. The number of species of pennate diatoms is only slightly greater than that of centric diatoms. Species of the genera Chaetoceros and Thalassiosira predominate among the centric diatoms, and species of the genera Navicula, Fragilaria and Gomphonema predominate among the pennate ones.

The predominance of diatoms is on the whole characteristic of the flora of the Arctic Basin, and has been noted in the past by other authors [Shirshov, 1937; Usachev, 1961; Bursa, 1961; Kawamura, 1967]. The table given below lists all the species and their occurrence by months. The 7th column in the table gives the species identified by us in an ice sample taken on Sept. 27th. As we can see, this sample contains only a few more species of pennate diatoms, but the number of cells, predominantly Fragilaria, is almost 200 times greater than in the sample taken from a lead on Sept. 26th (fig. 2).

A similar picture was observed by B.Kh. Buynitsky et al. [1977]. In the samples taken in Alasheyev Bay (Antarctica) in 1969, the average abundance of algal cells was considerably higher than in the water. The authors believe that the salt capsules of

ice not only help keep the cells alive, but also enable them to reproduce, though slowly.

The table gives the dates when the samples processed by concentration were also used to characterize the qualitative composition of the phytoplankton.

Occurrence of algae by months

Species	Date of sampling					
	June 9*, 24*, 25*, 28	July 3*, 7, 11, 19*, 22	Aug 14, 19, 21, 27*	Sept 3, 14, 26	Oct 7, 14	ice sample Sept 27
1	2	3	4	5	6	7
Centric						
Bacterosira fragilis Gran	-	-	+	-	-	-
Chaetoceros compressus Laud.	-	-	-	+	-	-
Ch. filiforme Meunier	-	-	-	+	-	-
Ch. fragile Meunier	-	-	+	+	-	+
Ch. gracilis Schütt	-	-	-	+	+	+
Ch. holsaticus Schütt	-	-	-	+	-	-
Ch. ingolfianus Ostf.	-	-	+	-	-	-
Ch. mitra Cl.	-	-	+	-	-	-
Ch. socialis Laud.	-	+	+	-	-	-
Coscinodiscus spp.	+	+	+	+	+	+
Lauderia borealis Gran.	-	+	+	+	-	+
Leptocylindrus danicus Cl.	-	-	-	-	+	-
Melosira arctica Dicie	+	+	+	-	-	-
Porosira glacialis Jorg.	-	+	+	+	+	+
Rhizosolenia hebetata f. *hiemalis* Gran	-	-	+	-	-	-
R. styliformis Bright.	-	-	-	+	-	+
Schroderella delicatula Pav.	-	-	+	-	-	-
Thalassiosira bioculata Ostf.	-	-	+	+	-	-
T. decipiens Jorg.	-	-	-	+	+	-
T. gravida Cl.	-	-	+	+	+	-
T. hyalina Gran	-	+	+	-	+	-
T. nordenskioldii Cl.	-	-	+	+	-	+
T. polychorda Grun.	-	-	+	+	-	-

*Bathometric samples

(table continued)

1	2	3	4	5	6	7
P e n n a t e						
Achnanthes arctica Cl.	+	–	+	–	–	–
A. taeniata Grun.	–	+	+	+	+	+
Amphiprora kjellmanii Cl.	–	–	+	–	–	–
Amphora sp.	–	–	–	+	+	+
Cocconeis distans Greg.	+	–	–	–	–	–
Fragilaria cylindrus Grun.	–	+	–	–	–	+
F. oceanica Cl.	+	+	+	+	+	+
Gomphonema exiguum Ktz.	+	+	+	–	+	–
G. exiguum v. *arctica* Grun.	+	+	+	–	+	–
G. kamtschaticum Grun.	+	+	+	+	+	+
Gyrosigma sp.	–	+	–	–	–	–
Licmophora sp.	–	+	–	–	–	+
L. paradoxa v. *crystalina* Grun.	+	+	+	+	+	–
Navicula spicula Hickie	–	–	+	–	–	–
N. septentrionalis Gran	+	–	–	–	–	+
N. transitans Cl.	+	+	+	+	+	+
N. transitans v. *derasa* Grun.	–	–	–	+	–	–
N. transitans v. *incudiformis* Grun.	–	–	–	–	+	–
N. valida Cl. et Grun.	–	–	–	–	+	–
N. valida v. *minuta* Cl.	–	–	–	+	–	–
Nitzschia closterium W. Sm.	+	+	+	+	+	+
N. delicatissima Cl.	+	+	+	+	+	+
N. frigida Grun.	+	+	–	–	–	–
N. laevissima Grun.	+	+	–	+	–	–
Pleurosigma stuxbergii Cl.	+	+	+	+	–	+
Synedra sp.	–	–	–	–	+	–
Thalassionema nitzschioides Grun.	–	–	–	+	–	–
Thalassiothrix frauenfeldii Grun.	–	–	+	+	–	–
Tropidoneis longa Cl.	–	+	–	–	–	–
Dinoflagellatae	+	+	+	+	+	+
Silicoflagellatae	+	–	–	–	–	–
Cyanophycea	+	+	–	–	+	–

S e a s o n a l c h a n g e s i n t h e c o m p o s i t i o n a n d a b u n d a n c e o f p h y t o p l a n k t o n. Fig. 1 depicts the ratio of the number of species and the abundance of algae for each season on the average, from spring up to the beginning of winter. As we can see, the maximum

number of species is observed in August, and the minimum number in June. The number of pennate diatoms hardly changes from season to season, while the number of centric diatoms varies greatly; they are hardly observed in June, increase very insignificantly in July, and the maximum number of species is observed in August, more precisely during the second half of the month when biological summer begins in the Arctic. By the beginning of winter, the number of centric diatoms decreases significantly. (137

The abundance of the diatoms peaked in July (biological spring in the Arctic) and then decreased sharply in August; they approximated the August level in September and then again decreased sharply by the beginning of October.

S p r i n g. The life of the phytoplankton in the Arctic Basin is associated with the ice conditions which vary quite significantly in different places and during different years.

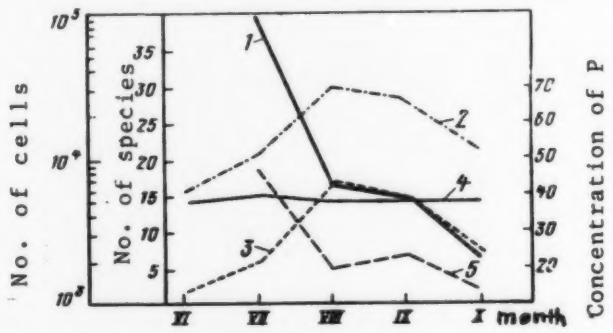

Fig. 1. Ratio of the number of species, the number of diatom cells (cells/l) and the concentration of phosphorus (μg/l) for each season on the average

1 - Number of cells; 2 - Total number of species; 3 - Number of centric forms; 4 - Number of pennate forms; 5 - Concentration of phosphorus

Biological spring in the high Arctic begins after the breaking up and movement of the ice; at different latitudes, this takes place at different times, but, in any case, the onset of spring blooming

is associated with the melting of the ice and the penetration of light into the water mass [Bogorov, 1938, 1941; Gran, 1932; Digby, 1953; Bursa, 1961].

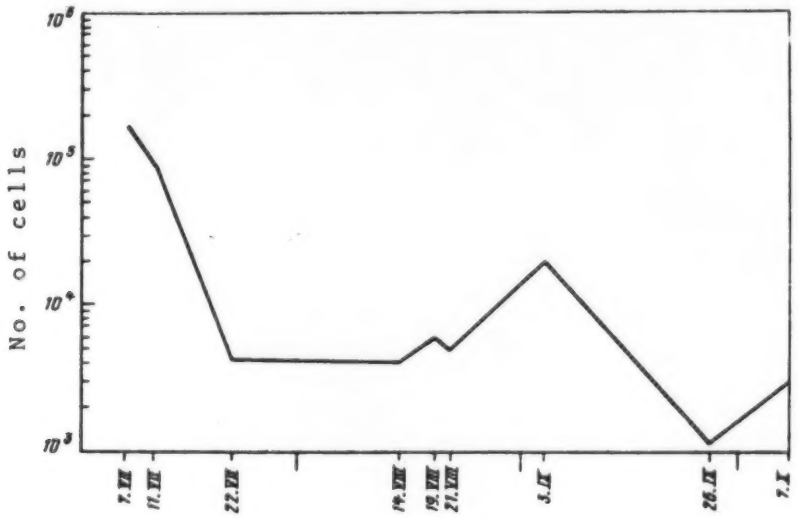

Fig. 2. Time distribution of the abundance of phytoplankton (cells/l)

According to our data, spring in the vicinity of the SP-22 station began at the end of June-the first days of July. By the end of the first week of July, we observed the mass blooming of algae, and the maximum abundance of phytoplankton reached 184,500 cells/l (fig. 2). The blooming consisted exclusively of pennate diatoms, i.e. Fragilaria oceanica, Nitzschia frigida, other species of Nitzschia and Licmophora. Centric diatoms, which on the whole are not characteristic of the spring condition of the phytoplankton, numbered three times fewer species and their abundance constituted less than 1% of the total abundance of phytoplankton during the blooming period. Blooming lasts for a very short period, and then decreases rapidly. The abundance of phytoplankton on July 22nd was already only 4100 cells/l. Some species,

such as Nitzschia frigida, are observed in maximum abundance during blooming, and by the end of July they are no longer found in the plankton (fig. 3). However, there are also pennate species, such as Gomphonema kamtschaticum, which are found in maximum abundance at the end of July.

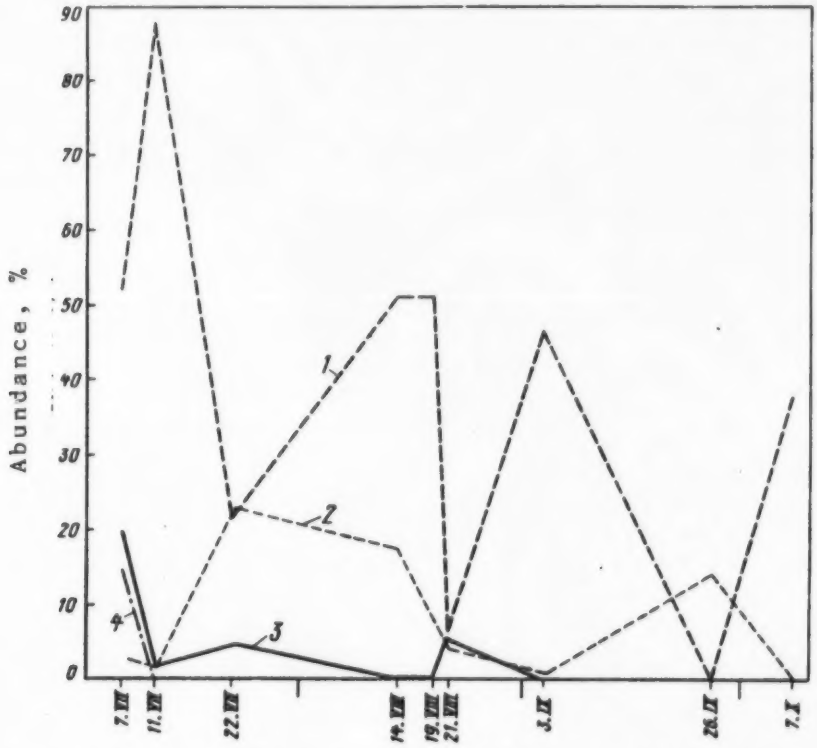

Fig. 3. Abundance (% of total number of diatom cells) of some species of pennate diatoms: 1 - Fragilaria spp.; 2 - Gomphonema kamtschaticum; 3 - Licmophora paradoxa; 4 - Nitzschia frigida

S u m m e r. From the middle of July, new species of centric diatoms, mainly Thalassiosira and Chaetoceros, begin to appear in the plankton. Some centric spring forms, such as Melosira arctica, complete their vegetation by this time (fig. 4). The number of pennate forms decreases, though insignificantly, and, at the same time, the abundance of centric forms increases, reaching the

maximum on August 21st (52% of the total abundance of diatoms). During this period, their abundance is slightly greater than that of the pennate species (2833 and 2200 cells/l respectively). The growing importance of centric diatoms during the Arctic summer was observed by Shirshov [1937, 1938] in the Chukchi and East Siberian seas, Bursa [1961) in the Igloolik area (Canadian Arctic) and by Kawamura [1967] in the Atlantic part of the Arctic. This condition of the phytoplankton points to the beginning of biological summer.

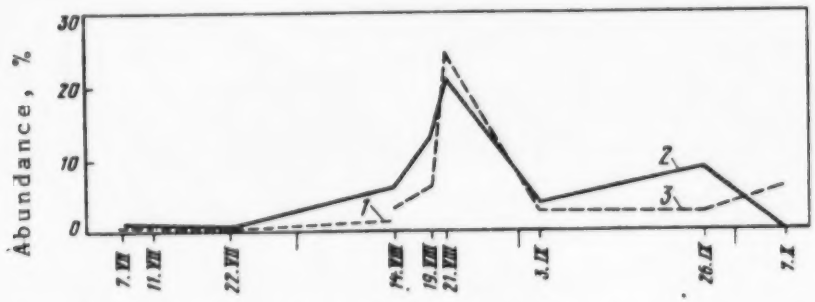

Fig. 4. Abundance (% of total number of diatom cells) of some species of centric diatoms: 1 - Melosira arctica; 2 - Thalassiosira sp.; 3 - Chaetoceros sp.

Why is it that centric forms appear during the clean-water (138) period, i.e. when large areas are free of ice? Bursa [1961] tends to regard the centric diatoms as the "sunshine" flora, as compared with the "shade-loving" pennate forms. It is possible that the centric and pennate diatoms represent two different ecological groups. It is a known fact that considerable light adaptation exists in Arctic diatoms, and it is possible that less light is required for the development of pennate algae. It may also be that the pennate forms require a greater concentration of nutrients for their development in comparison with the centric forms, i.e.

biogenic elements are found in excessive quantitites by the beginning of spring blooming when the pennate forms predominate. Fig. 1 shows the variation in the concentration of phosphorus by seasons (mean values for each season). As we can see from the diagram, the maximum concentrations of phosphorus are observed in July, the blooming period of the pennate diatoms. In August, the concentration of phosphorus sharply diminishes, and the abundance of the centric diatoms increases (fig. 5).

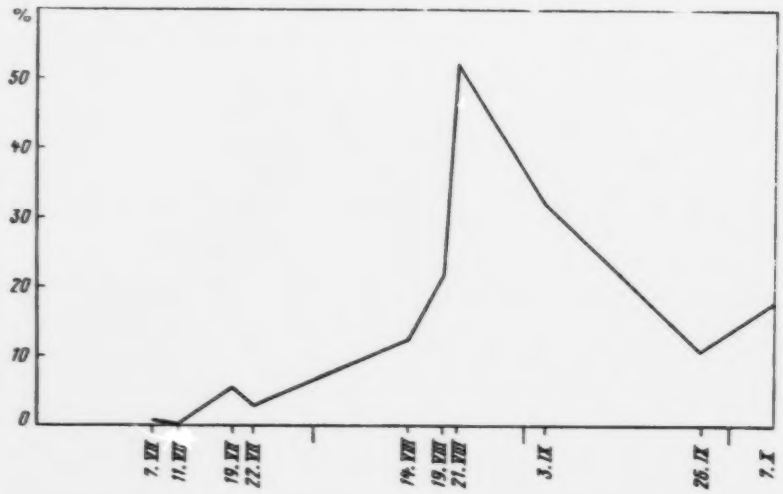

Fig. 5. Distribution of centric diatoms (% of total number of cells of all the diatoms)

We did not observe any increase in the abundance of peridineans during the summer. This could have been due to the fact that the temperature of the water in the lead during its existence was low, varying from -1.69 to - 1.71°C. Kawamura [1961] also observed very small quantities of dinoflagellates in the Atlantic part of the Arctic.

A u t u m n. Unfortunately, we have only two samples, taken on Sept 3rd and 26th, that provide us with information about the autumn condition of the phytoplankton. At the beginning of September, some of the species are still growing. At this time, various species of Fragilaria and Porosira glacialis predominate in numbers. At the beginning of September, we observed a second maximum of abundance of diatoms, though this maximum was 10 times smaller than the one observed on July 7th during spring blooming. It is difficult to say what caused it. According to Bogorov [1938], there is only one maximum of phytoplankton in the Arctic seas from the Kara to the Chukchi seas. By the end of September, spores and dead cells appear in the plankton, and a part of the species, having completed vegetation, descends into the deeper layers. (141)

In October (apparently the beginning of winter), we observed a sudden depletion of phytoplankton, i.e. the number of centric diatoms decreased by one-half. In comparison with September, the abundance of diatoms diminished approximately 3-fold on the whole, though it increased somewhat in comparison with Sept 20th (figs. 1 and 2).

V e r t i c a l d i s t r i b u t i o n o f p h y t o p l a n k t o n. Unfortunately, the data by which we can judge the vertical distribution of phytoplankton is quite scarce; they were obtained from only three bathometric stations, st. 12 on Aug 27th, st. 15 on Sept 14th and st. 17 on Oct 14th, where the samples were taken from the 10, 25, 50 and 100 m level, and at stations 12 and 17 from the 200 m level as well. The maximum of

phytoplankton was observed at st. 12 in the 10 m layer (10,000 cells/l), after which the number of cells gradually diminished, and at a depth of 200 m not even dead cells were observed. At st. 15, the abundance of phytoplankton in the 25 m layer was somewhat higher than in the 10 m layer (about 3000 and 2000 cells/l respectively); it then decreased and amounted to only 200 cells/l in the 100 m layer. The distribution of phytoplankton at st. 17 differed from that of the other two stations; the number of cells at that station increased, rather than decreased with depth (1000 cells/l at a 10 m depth, and about 6000 cells/l at 100 and 200 m). It is difficult to say what causes this unusual distribution, and so we will refrain from any conclusion regarding this.

To summarize, we would like to review the facts established by us. The taxonomic composition and abundance of the phytoplankton community in the study area are determined by the predominance of low temperatures, the presence of ice and the illumination conditions. Spring began with the blooming of pennate diatoms which reached their maximum abundance (184,500 cells/l) on July 7th. Summer began approximately in the second half of August with an increase in the role of centric diatoms which reached their maximum numbers on August 21st (52% of the total abundance of diatoms). We observed two peaks in the abundance of diatoms, a spring peak on July 7th and a smaller autumn maximum on September 3rd. As the amount of light diminished at the end of September and beginning of October, we observed a noticeable decrease in the number of species of algae and a sharp drop in their numbers (3000 cells/l on October 7th).

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